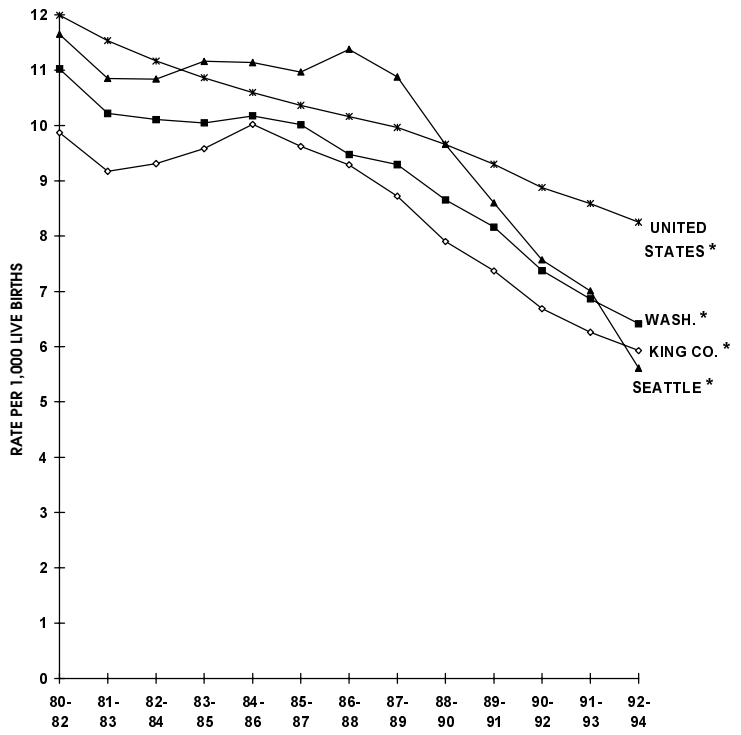
CHAPTER II. TRENDS IN INFANT MORTALITY

This chapter examines trends in infant mortality using data from vital records. It also suggests explanations for these trends. Subsequent chapters explore in more detail the infant mortality rates of specific racial groups and regions within King County.

TRENDS IN INFANT MORTALITY FOR THE UNITED STATES, WASHINGTON, KING COUNTY AND SEATTLE

The infant mortality rate in King County in 1994 (the most recent year for which data are available) was 6.3 deaths per 1000 livebirths. The Seattle rate was 4.8 per 1000, the Washington rate was 6.2 per 1000 and the United States rate was 7.9 per 1000. The number of infants who died in King County in 1994 was 138 and the number in Seattle was 31.

FIGURE 2.1:
INFANT MORTALITY RATES
U.S., WASHINGTON, KING COUNTY, SEATTLE
THREE YEAR ROLLING AVERAGES, 1980-1994



*TRENDS FROM 1988-1994 SHOW A STATISTICALLY SIGNIFICANT DECREASE.
SOURCE: BIRTH AND DEATH CERTIFICATES.

The infant mortality rates in King County and Seattle have declined substantially over the past fifteen years. In the County, the rate decreased by 40 percent since 1980 and in Seattle, by an even greater 63 percent. While 187 infants died in King County in 1985, the count decreased to 138 in 1994. In Seattle, 84 infants died in 1988 compared to 31 in 1994.

This decline has been most apparent in recent years. In the early 1980s, the rate decreased at a moderate pace, and then increased in the mid-1980s. In the late-1980s and early 1990s, a favorable trend emerged as the rate declined more rapidly than at any other time during the past fifteen years (Figure 2.1, Table 2.1 and Table B.1 in Appendix B).[a]

This pattern was most notable in Seattle where the rate decreased an average of 6.3 percent per year from 1980 to 1983, then *increased* by 3.2 percent per year from 1983 to 1988, and then dropped steeply by 10.2 percent per year from 1988 to 1994. A similar pattern was apparent in King County.

[a] The appendices contain tables with more detailed data.

TABLE 2.1
PERCENT CHANGE IN INFANT MORTALITY RATE
U.S., WASHINGTON, KING COUNTY, AND SEATTLE

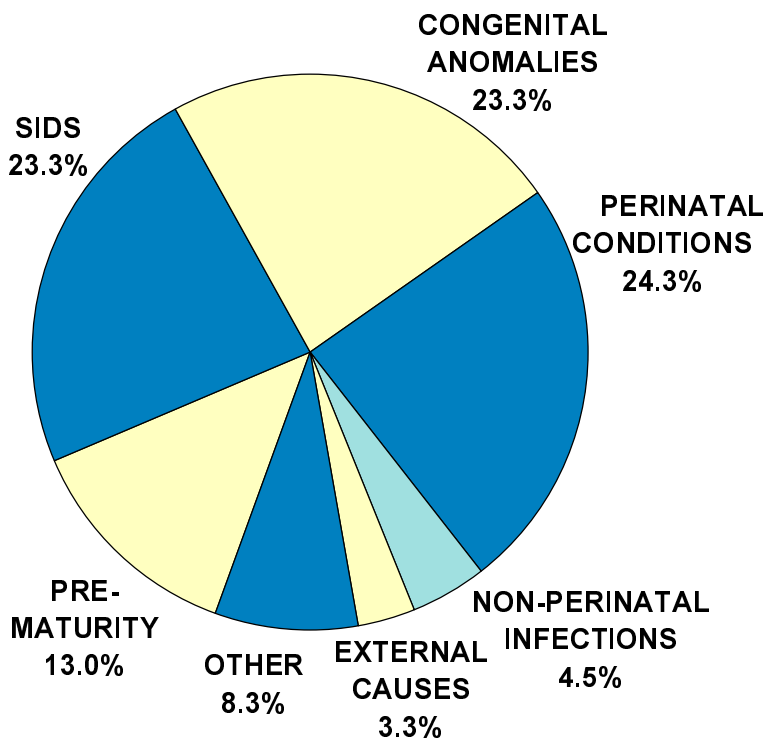
LOCATION	1ST TIME PERIOD: 1980-1983	2ND TIME PERIOD: 1983-1988	3RD TIME PERIOD: 1988-1994	TOTAL TIME PERIOD: 1980-1994
UNITED STATES	decrease 11%	decrease 11%	decrease 21%	decrease 37%
WASHINGTON	decrease 19%	decrease 5%	decrease 31%	decrease 47%
KING COUNTY	decrease 20%	increase 8%	decrease 30%	decrease 40%
SEATTLE	decrease 19%	increase 16%	decrease 61%	decrease 63%

SOURCE: BIRTH AND DEATH CERTIFICATES.

TRENDS IN SPECIFIC CAUSES OF INFANT MORTALITY

The infant mortality rate is a summary indicator describing the death rate among infants from all causes of death combined. These causes are quite diverse, and each is associated with its own set of risk factors and prevention strategies. Therefore, it is useful to examine the specific causes in more detail.

FIGURE 2.2
CAUSES OF INFANT MORTALITY
KING COUNTY
THREE YEAR AVERAGE, 1992-1994

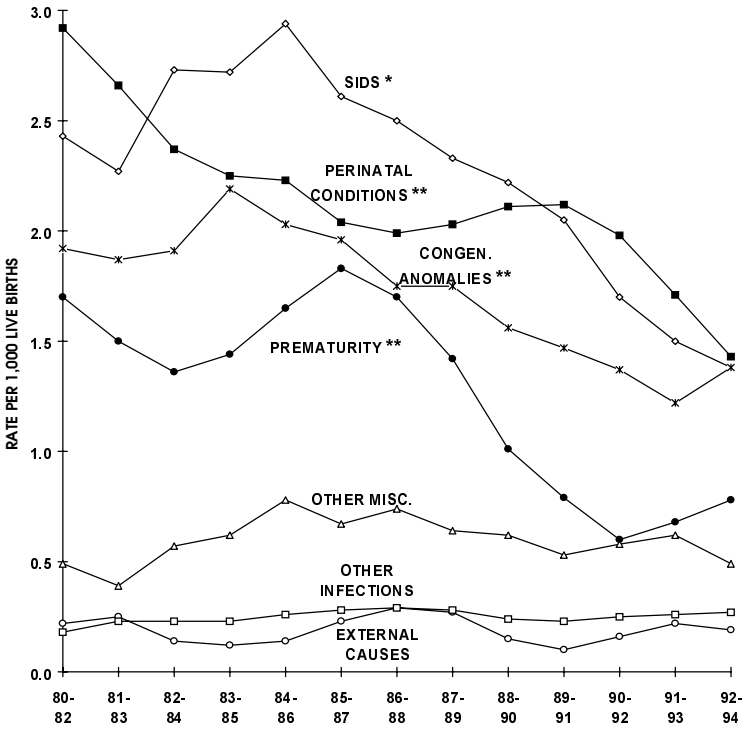


SOURCE: BIRTH AND DEATH CERTIFICATES.

The three leading causes of infant deaths in the 1992 to 1994 period were perinatal conditions (conditions causing death during the first 27 days of life, including problems with the lungs, birth-related injuries, suffocation during birth, and infections), congenital anomalies (birth defects), and SIDS (Sudden Infant Death Syndrome). Each accounted for slightly less than a quarter of all deaths. Deaths due to prematurity[b] also figured prominently and contributed 13 percent of the total (Figure 2.2). Infections (such as pneumonia or meningitis) occurring after the perinatal period, external causes (injuries, both intentional and unintentional), and miscellaneous other causes each added smaller numbers of cases. Definitions of each of these causes of death are contained in Appendix A.

[b] The categorization of causes of infant death is limited by the overlap between the perinatal and prematurity groups. A large portion of infants assigned to the perinatal category were born prematurely. Deciding whether the death of these infants was due primarily to their prematurity or to a complication in the perinatal period is imprecise, probably resulting in the classification of some infants whose deaths were due primarily to prematurity into the perinatal category.

FIGURE 2.3
CAUSES OF INFANT MORTALITY
KING COUNTY
THREE YEAR ROLLING AVERAGES, 1980-1994



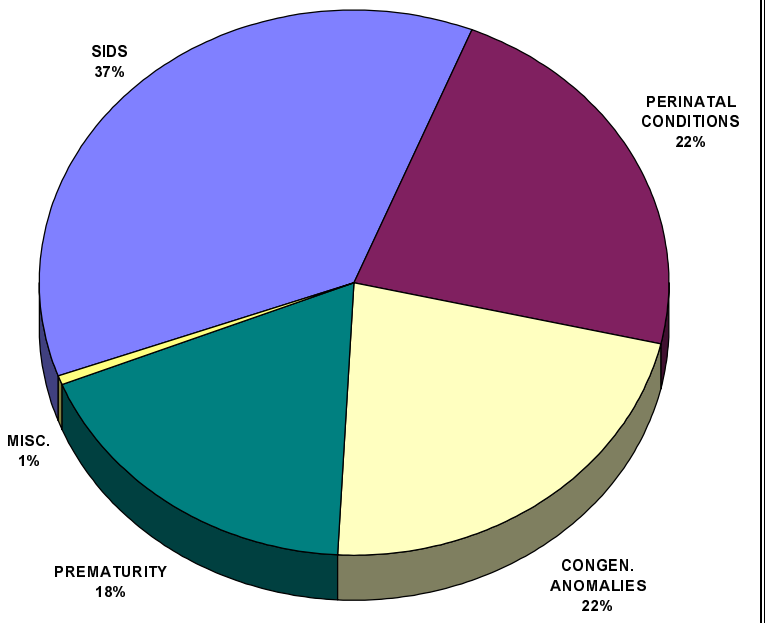
* TRENDS FROM 1984-1994 SHOW A STATISTICALLY SIGNIFICANT DECREASE.

** TRENDS FROM 1980-1994 SHOW A STATISTICALLY SIGNIFICANT DECREASE.

SOURCE: BIRTH AND DEATH CERTIFICATES.

Significant decreases in the rates of all four of the major causes of infant death occurred during the 1980-94 time period (Figure 2.3). Each declined by more than 50 percent from their high points in the 1980s to their low points in the early 1990s. No significant changes occurred in the rates of death from other infections and external causes. While perinatal conditions and SIDS death rates have continued to decline through 1994, the prematurity death rate seems to have leveled in recent years. Explanations for these findings are discussed in more detail later in this section.

FIGURE 2.4
PROPORTION OF DECREASE IN INFANT MORTALITY FROM 1983-1985 TO 1992-1994 ATTRIBUTABLE TO SPECIFIC CAUSES KING COUNTY



SOURCE: BIRTH AND DEATH CERTIFICATES.

The King County infant mortality rate peaked in 1984 and reached its low point in 1993. The declining SIDS rate contributed 37 percent of this decrease, while the declining rates of death from perinatal conditions and congenital anomalies each contributed 22 percent and prematurity contributed 18 percent (Figure 2.4).

HOW CAN THE DECLINE IN INFANT MORTALITY BE EXPLAINED?

The factors influencing infant mortality are complex and only partially understood. This section explores some of the local influences on the infant death rate. Declining risk factors for infant mortality were an important part of the explanation. We discuss possible explanations for the changing occurrence of these risk factors, including recent improvements in the delivery of health services to pregnant women. Another important contributor to the lower infant mortality was recent progress in medical science.

CHANGING RISK FACTORS FOR INFANT MORTALITY

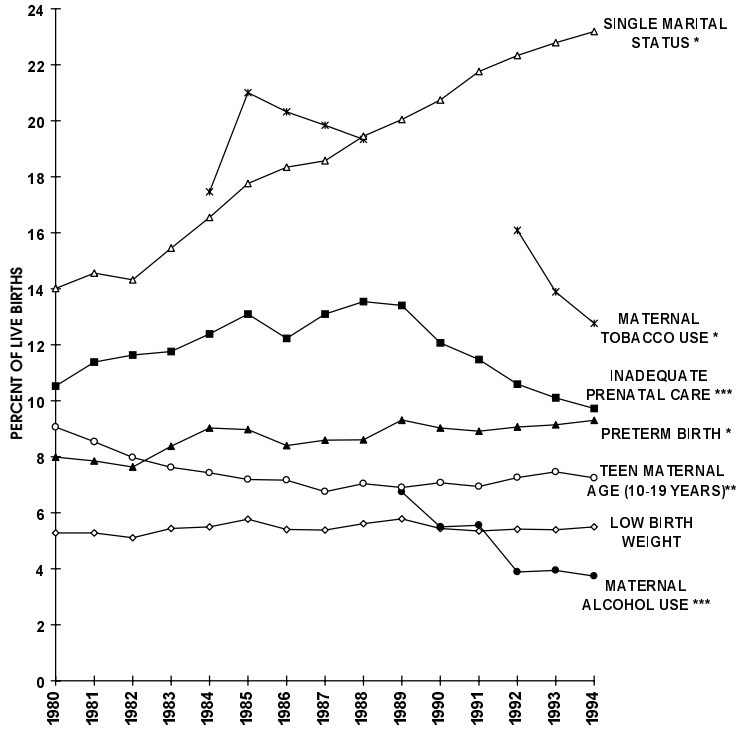
A *risk factor* for infant mortality is a characteristic or condition that increases the chances that an infant may die. Many risk factors have been identified through epidemiological research.[1-23] The occurrence of an infant's death can be viewed as the culmination of a chain or web of multiple risk factors. Some risk factors (*distal risk factors*) may be "further away" from the death and exert their influence by causing the occurrence of other risk factors (*proximal risk factors*) "closer" to the death. Oftentimes, proximal risk factors are physiologic or pathologic conditions. For example, smoking during pregnancy increases the risk of infant death. In part, it does this through slowing fetal growth in utero as well as causing premature birth, resulting in a baby with a low birthweight. Low birthweight, a physiologic condition, is one of the strongest risk factors for infant death. In this example, smoking is a distal risk factor (further away) and low birthweight is a proximal (closer) risk factor. Low income and race (more precisely, racism) are fundamental distal risk factors which influence the occurrence of many of the other risk factors for infant death.

In this section, we consider the physiologic, proximate risk factors of low birthweight and prematurity as well as a number of distal risk factors such as health-related behaviors and problems with access to health services. Part of the explanation for the observed decrease in infant mortality lies in the recent favorable trends in some of these risk factors. Race as a risk factor is discussed in Chapter III.

The risk factors considered in this section ("measured risk factors") are limited to those included on the birth certificate, the only currently available source of routinely collected risk factor data[c]. Many other known risk factors go "unmeasured", in addition to other unidentified ones. Chapters VI-IX discuss the occurrence of some of these unmeasured factors among cases of infant deaths, as revealed by the Infant Mortality Review process.

Among the measured risk factors available from the birth certificate, the rates of smoking, alcohol use, teen births and inadequate prenatal care decreased in recent years, while the proportion of births to unmarried parents increased.

FIGURE 2.5
LIVEBIRTHS WITH SELECTED RISK FACTORS
KING COUNTY
1980-1994



* THIS TREND FROM 1980-1994 IS A STATISTICAL SIGNIFICANT INCREASE.
** THIS TREND FROM 1980-1994 IS A STATISTICAL SIGNIFICANT DECREASE.
*** THIS TREND FROM 1989-1994 IS A STATISTICAL SIGNIFICANT DECREASE.
SOURCE: BIRTH AND DEATH CERTIFICATES.

The low birthweight rate has not changed while the rate of premature births has increased slightly. Trends in these risk factors are summarized in Figure 2.5 and Table 2.2.

For each risk factor, the first column of Table 2.2 shows the percentage of all births with the risk factor present during the 1983 to 1985 period when infant mortality was at its highest point during the period covered by this report (1980 to 1994). The next two columns display the rate during the most recent period (1992 to 1994) and the percent change in the rate between the two periods.

The table also displays the increased risk (odds ratio) of dying among infants with the risk factor compared to those without the factor. Both "crude" and "adjusted" odds ratios are presented. The crude ratio shows the risk for each factor examined in isolation from all the others.

However, many of these factors are interrelated. For example, infant mortality is associated with smoking, alcohol consumption and inadequate prenatal care. Women who smoke are also more likely to

[c] In the near future, data from PRAMS (the Pregnancy Risk Assessment Monitoring System) will be available and will provide information on a broader range of risk factors for poor birth outcomes among pregnant women in Washington State and King County.

drink, so some of the increased risk associated with smoking may be due to the higher drinking rate among smokers, and vice-versa. Some of the effects of prenatal care on reducing infant mortality may be due to its ability to influence pregnant women to decrease their smoking and drinking. But prenatal care may also reduce infant mortality through other pathways. The increased risks associated with teen births and births to unmarried women are due in part to the association of these factors with other factors, such as smoking and inadequate prenatal care. One way to clarify the situation is to do a statistical analysis which simultaneously examines the effects of all these factors and provides an "adjusted" risk for each factor which reflects the independent contribution of each factor. The odds ratios for low birthweight and prematurity are not adjusted, because they are proximal, final common pathways for many risk factors. The adjusted odds ratios for smoking, alcohol, teen birth, single marital status and prenatal care have each been adjusted for all the other factors in this group. In the following chapter on race and infant mortality, we discuss the combined effects of these risk factors with race and income.

The next column displays the proportion of infant deaths associated with each factor (population attributable risk). For example, nine percent of all infant deaths were associated with smoking, after adjusting for the other distal risk factors. In other words, eliminating smoking among pregnant women has the potential to decrease infant mortality by nine percent, independently of interventions addressing the other risk factors in the table.

TABLE 2.2
TRENDS IN SPECIFIC RISK FACTORS FOR INFANT MORTALITY
KING COUNTY FROM 1983-1985 TO 1992-1994

	PERCENT OF BIRTHS			ODDS RATIO: INCREASED RISK OF INFANT DEATH	ODDS RATIO: INCREASED RISK OF INFANT DEATH	% INFANT DEATH
RISK FACTOR	1983 TO 1985	1992 TO 1994	PERCENT CHANGE	ASSOCIATED WITH FACTOR (1992-1994) CRUDE RATE (95% CI)	ASSOCIATED WITH FACTOR (1992-1994) ADJUSTED (95% CI)***	ATTRIBUTABLE TO FACTOR (PAR%)**** (1992-1994)
LOW BIRTHWEIGHT	5.57	5.43	-0.14%	20.4 (15.7-26.4)	----	---
PRETERM BIRTH (CALCULATED)	8.79	9.17	0.38%	9.1 (7.0-11.8)	----	---
MATERNAL SMOKING	19.23*	14.26	-4.97%	2.3 (1.7-3.1)	1.7 (1.2-2.5)	9.1
MATERNAL ALCOHOL USE	N/A**	3.86	N/A	1.3 (0.7-2.4)	1.1 (0.6-2.2)	0.4
INADEQUATE PRENATAL CARE	12.43	10.15	-2.28%	1.7 (1.3-2.2)	1.5 (1.1-2.0)	4.8
YOUNG MATERNAL AGE (10-19 YEARS)	7.41	7.32	-0.09%	1.9 (1.3-2.8)	1.1 (0.7-1.8)	0.7
SINGLE MARITAL STATUS	16.61	22.76	6.15%	2.0 (1.5-2.6)	1.5 (1.1-2.2)	10.2

* RATES ARE UNAVAILABLE BEFORE 1984, SO THE RATES ARE PRESENTED FOR ONLY TWO YEARS (1984-1985).
** RATES ARE UNAVAILABLE BEFORE 1989, SO NO RATE IS PRESENTED FOR 1983-1985.
*** THE ODDS RATIO FOR EACH FACTOR IS ADJUSTED FOR THE OTHER FACTORS USING LOGISTIC REGRESSION. NO ADJUSTMENT WAS MADE FOR LOW BIRTHWEIGHT OR PREMATURITY
**** CALCULATION OF PAR% USING ADJUSTED ODDS RATIOS

LOW BIRTHWEIGHT

An infant is considered to have a low birthweight if she or he weighs less than 2500 grams (5 1/2 pounds) at birth. Low birthweight is the single strongest predictor of infant death. In King County, an infant with a low birthweight was 20.4[d] times more likely to die than an infant of normal weight. This risk factor accounted for 31 percent of all infant deaths during the 1992 to 1994 period. Infants born with very low birthweight (less than 1500 grams or 3.3 pounds) had an extremely high risk of dying. Nearly a quarter of them died during the first year of life in the 1992 to 1994 period. They were 86 times more likely to die than infants with normal birthweights. Low birthweight infants may develop problems breathing, are more prone to infections and can develop neurological difficulties, all of which may lead to death. An infant can be born with low birthweight because of slow growth during pregnancy, premature birth, or both. Many of the other risk factors for infant mortality have their impact because they in turn cause low birthweight. The low birthweight rate of 5.5 percent of all livebirths has not changed since 1980.

PRETERM BIRTH

An infant is considered preterm if he or she is born before completing 37 weeks gestation. Preterm birth is a strong predictor of infant death. Such infants are 9.1[e] times more likely to die. Prematurity was associated with 14.8 percent of infant deaths. Prematurity and low birthweight are closely linked. Nearly one third (32.5 percent) of preterm births result in low birthweight infants and most (71.4 percent) infants who are born with low birthweight are underweight because they are born prematurely. The birth rate for premature babies increased significantly by 16 percent since 1980. In 1994 it made up 9.3 percent of all births.

MATERNAL SMOKING

A mother was considered a smoker if her baby's birth certificate indicated any smoking during pregnancy. Smoking increased the risk of infant death 2.3 times (risk adjusted for other measured risk factors = 1.7) and was associated with 9.1 percent of deaths. In 1994, 13 percent of mothers reported smoking. The rate decreased by 39 percent from a high of 21 percent in 1985, the first year with complete reporting.

MATERNAL ALCOHOL USE

A mother was classified as using alcohol during her pregnancy if the birth certificate indicated any use during pregnancy. Alcohol use was associated with a 1.3-fold increase (adjusted risk = 1.1) in infant death. In 1994, 3.7 percent of mothers used alcohol during pregnancy, compared to 6.7 percent in 1989, the first year such data were collected.

INADEQUATE PRENATAL CARE

Measurement of the adequacy of prenatal care is inexact. Information about the content of care (i.e. counseling offered, tests performed, treatment provided) is not readily available, so most measures assess the quantity of care. We have used the Kotelchuck Index, which takes into account both how early in her pregnancy a mother began her care and the number of visits she made.[24] Inadequate prenatal care was associated with a 1.7-fold increase (adjusted risk = 1.5) of infant death and 4.8 percent of infant deaths

---

[d] This is the crude or unadjusted odds ratio. After adjustment for gestational age, the odds ratio for low birthweight decreased to 9.3, indicating that part of the effect of low birthweight on infant mortality was related to prematurity.

[e] This is the crude or unadjusted odds ratio. After adjustment for birthweight, the odds ratio for prematurity decreased to 2.9, indicating that part of the effect of prematurity on infant mortality comes through the relationship between low birthweight and prematurity. Most low birthweight infants are premature.

were attributable to it. The rate of inadequate care increased from 1980 to a maximum of 13.5 percent of all births in 1988, and then steadily declined, reaching an improved 9.7 percent in 1994.

YOUNG MATERNAL AGE

Young maternal age may best be thought of as a marker for other, unmeasured social risk factors. Infants born to mothers age 10 to 19 years old were 1.9 times more likely to die than those born to older mothers (adjusted risk = 1.1, indicating that nearly all the increased risk associated with young age is accounted for by the higher rate of the other risk factors among young women). Teen births were associated with less than one percent of infant deaths in the 1992 to 1994 period. The birth rate among women age 10 to 19 increased steadily to a peak of 36.6 births per 1,000 women age 10-19 in 1992, and then declined to 32.7 per 1,000 by 1994. The percentage of all births among women age 10 to 19 years old decreased from 8.9 percent in 1980 to 7.0 percent in 1994, reflecting both the lower birth rate among teens and a higher rate among older women.

OLDER MATERNAL AGE

Women who are 35 and older are at higher risk of certain complications of pregnancy, including congenital anomalies, low birthweight, delayed fetal growth and neonatal deaths,[25] although such problems tend to be uncommon. However, our analysis did not find that infants born to women age 35 and older in King County were at increased for infant death. In King County, a larger proportion of all births in recent years have occurred among women age 35 and older: in 1980 they accounted for only 5.4 percent of all births while in 1994 they contributed 17.1 percent. The birth rate among this age group increased from 8.8 per 1000 to 18.2 per 1000.

SINGLE MARITAL STATUS

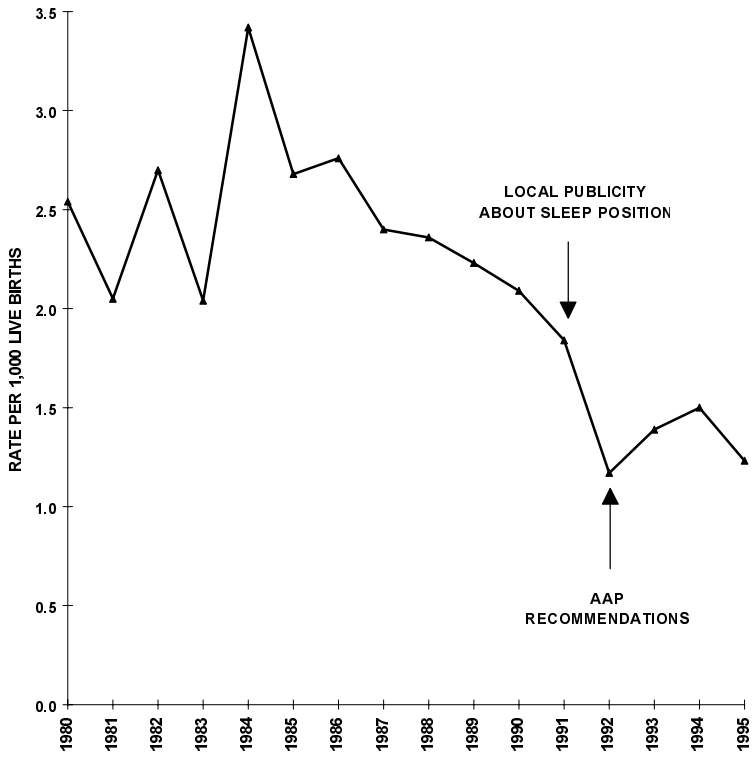
The marital status of the newborn's parents influences birth outcomes through many pathways. Usually, when the parents are not married, the mother assumes responsibility for raising the child, often under adverse conditions of limited income and social support. Unmarried status is thus a marker for other, unmeasured, social risk factors.[26] Simply increasing the proportion of parents who are married will not address these risk factors. An infant born to unmarried parents was 2.0 times more likely to die (adjusted risk = 1.5) than one born to married parents and 10.2 percent of infant deaths were associated with this risk factor. The proportion of births to unwed parents increased by 54 percent since 1980, growing from 14 percent to 22 percent of all births.

It is clear that not all of the decline in infant mortality can be explained by changes in measured risk factors or improved health services. Statistical analysis indicates that the measured risk factors of maternal age, smoking, alcohol use, inadequate prenatal care and unmarried parents explain at most a quarter of infant deaths. Other important determinants of infant health that are not routinely measured in vital statistics records, such as socioeconomic conditions, various maternal behaviors, and the social environment therefore have a major influence on the infant mortality rate. We next consider two important "unmeasured" factors: sleep position and income. Additional factors derived from the Infant Mortality Review are discussed in Chapters VI-IX.

SLEEP POSITION

One important risk factor not currently measured, and which most likely played a major role in the declining rate of infant mortality, is an infant's sleep position. Numerous studies have shown that infants who sleep prone (on their stomachs) are at increased risk of dying from SIDS, [27] [28] [29] [30] [31] [32] [33] including one study done in King County.[34]

FIGURE 2.6
SIDS RATE
KING COUNTY
1980-1995



NOTE: THE 1995 RATE IS A PROVISIONAL ESTIMATE.
SOURCE: BIRTH AND DEATH CERTIFICATES.
AAP=AMERICAN ACADEMY OF PEDIATRICS

These studies have also demonstrated that communities which develop campaigns that encourage parents to position their infants in a non-prone sleep position are successful in decreasing the rate of prone sleeping and the SIDS rate. The SIDS rate in King County dropped during 1991 and 1992, when recommendations about sleep position and SIDS were brought to the attention of health providers and parents by local experts and the American Academy of Pediatrics (AAP) (Figure 2.6).

No local data exist on the frequency with which infants are placed to sleep on their stomachs, so we cannot report on trends in sleep position. We do know from the Infant Mortality Review that between 1990 and 1993, 72 percent of the infants dying from SIDS in King County were placed to sleep in the prone position before they died.

SOCIOECONOMIC STATUS

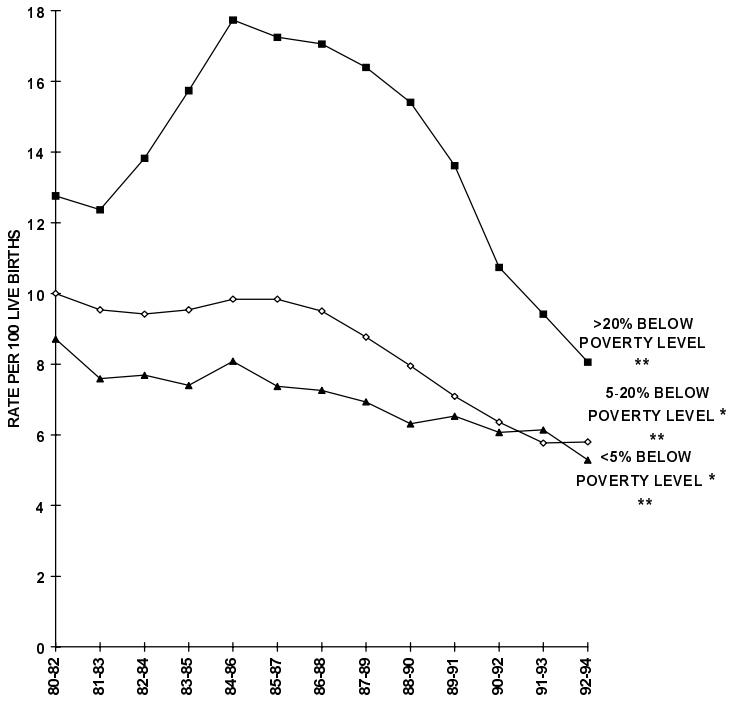
Socioeconomic status is a fundamental determinant of infant mortality. Universally, infants of low socioeconomic status have higher infant mortality rates. [35] [36] [37] [38] [39] King County is no exception. The only measure of socioeconomic status that is readily available from birth certificates (added in 1992) is the number years of education completed by the infant's mother. Infants born to mothers who have not completed high school were 1.8 times more likely to die than those born to mothers with more education during the 1992-94 period (95% CI=1.2-2.7).[f]

[f] The increased risk is the same if the analysis is restricted to women 25 years and older. After adjusting for maternal age, smoking and alcohol use, inadequate prenatal care and marital status, the odds ratio decreased to 1.3.

Another measure of socioeconomic status is low income. While no easily accessible data[g] exist indicating how many King County infants are born into poverty, we can compare infant mortality rates among poor and better-off areas within the county. The U.S. Census provides data for each census tract on the proportion of female residents age 12 to 64 who live in households with incomes below the poverty line.[h] A census tract is a geographic area which contains approximately 4,000 residents; there are 285 census tracts in King County. We grouped the census tracts into those in which more than 20 percent of the female population age 12 to 64 lived in poor households (high poverty tracts), those in which 5 to 20 percent were below poverty (medium poverty tracts), and those in which fewer than 5 percent were below the poverty level (low poverty tracts).

The infant mortality rate in the high poverty tracts has been consistently higher than the rate in the medium and low poverty tracts (Figure 2.7). During the 1984 to 1986 period, infants living in high poverty areas had an infant mortality rate more than twice that of infants living in low poverty tracts.

FIGURE 2.7
INFANT MORTALITY RATES
BY CENSUS TRACT POVERTY LEVEL IN KING COUNTY
THREE YEAR ROLLING AVERAGES, 1980-1994



* THIS TREND FROM 1980-1994 IS A STATISTICAL SIGNIFICANT DECREASE
** THIS TREND FROM 1985-1994 IS A STATISTICAL SIGNIFICANT DECREASE
SOURCE: BIRTH AND DEATH CERTIFICATES.

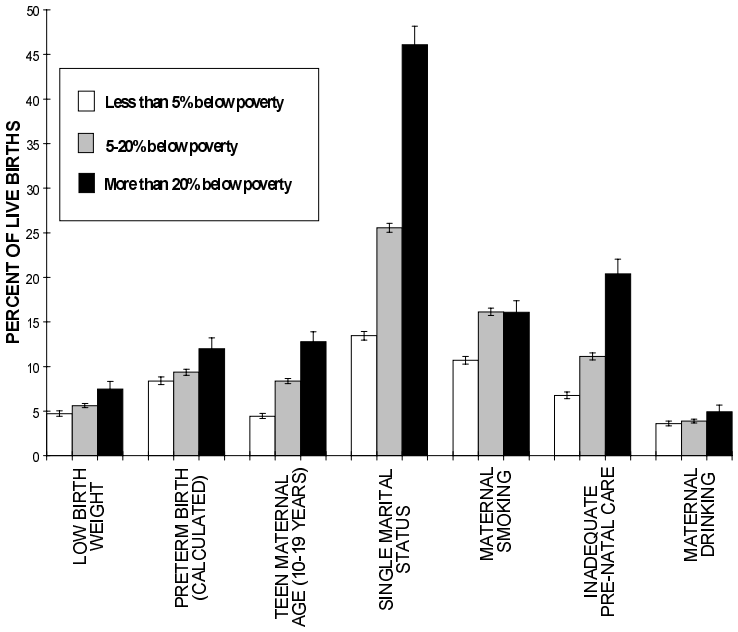
By the 1992 to 1994 period, the rate in the high poverty areas, although still exceeding the rate in the low poverty areas, was only 1.5 times higher. This improvement was due to the striking 55 percent decline in the rate in the high poverty areas. Less substantial, but still important declines of 41 percent and 34 percent in the medium and low poverty areas, respectively, also occurred during this interval.

Thus, declining levels of infant mortality among high poverty areas explains some of the decrease in the overall King County rate. The decline in infant deaths in the high poverty areas was, in turn, partially due to improvements in the risk factor levels in these areas.

[g] Birth certificates do not assess maternal income. Information on source of payment for prenatal care has been collected since 1992. Source of payment can serve as a proxy for income because mothers whose source is classified as Medicaid or charity care are likely to have low incomes. The birth certificate also contains information on the educational attainment of the mother, which is an important measure of socioeconomic status. However, information on education is missing on 15.5 percent of birth certificates.

[h] $12,674 per year for a four-person household in 1989, the year for which the Census collected information.

FIGURE 2.8
RISK FACTORS FOR INFANT MORTALITY
BY CENSUS TRACT POVERTY LEVEL, KING COUNTY
THREE YEAR AVERAGE, 1992-1994



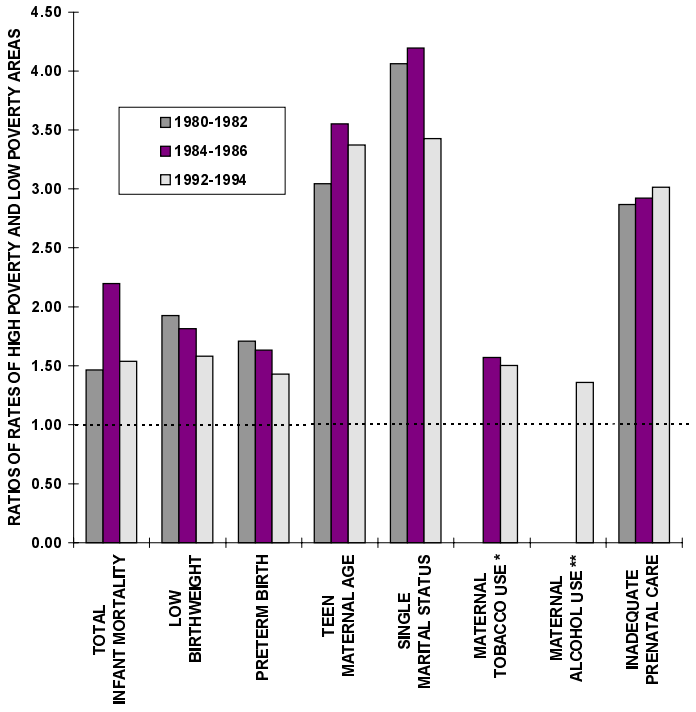
SOURCE: BIRTH AND DEATH CERTIFICATES.

Low income populations experienced higher levels of all the measured risk factors for infant death.

Relative to low poverty areas, the high poverty areas had rates of low birthweight 1.6 times as high, preterm birth 1.4 times as high, smoking 1.5 times as high, alcohol use 1.4 times as high, births to young mothers 2.9 times as high, births to unmarried parents 3.4 times as high and inadequate prenatal care 3.0 times as high (Figure 2.8).

Although the mothers in the high poverty areas had higher levels of risk factors for problems with births and their infants' health, these risk factors became less frequent over the most recent five years (Figure 2.9).

FIGURE 2.9
RATIOS OF BIRTH INDICATORS
HIGH POVERTY TO LOW POVERTY AREAS
KING COUNTY, 1980-1994



*DATA ON TOBACCO STARTED TO BE COLLECTED SINCE 1984
**DATA ON ALCOHOL STARTED TO BE COLLECTED SINCE 1989
SOURCE: BIRTH AND DEATH CERTIFICATES.

The ratios of the risk factor levels in the high poverty areas to the levels in the low poverty areas have also generally declined (Figure 2.9), contributing to the narrowing of the gap in infant mortality.

In addition to these favorable changes within the high poverty areas a smaller proportion of all births took place in high poverty areas over the past ten years. In the 1984-86 period, 7.4 percent of all births took place in high poverty areas, compared to 6.5 percent in 1992-94.

These improvements are all the more noteworthy because there has been little change in the proportion of the population living in poverty and a widening of the gap in income between rich and poor in recent years. For example, in 1989 the median income in the low poverty areas was 2.6 times higher than that in the high poverty areas. By 1994, this ratio rose to 2.7.[i]

In summary, despite widening income inequity and little change in the proportion of people living in poverty, the impact of socioeconomic inequity on infant mortality diminished. The decreased effect of income on infant mortality seems in part to be due to fewer infants being born in high poverty areas as well as improved birth outcomes among those who are born in these areas.

[i] Data sources: US Census and Claritas, Inc.

To further improve birth outcomes among the disadvantaged, interventions must continue to address risk factors for infant death in this population. The measured risk factors discussed above explain only a portion of the increased infant mortality in the high poverty areas. Many other unmeasured risk factors also occur more commonly among low income populations, including:

- Lack of social support
- Stress
- Unintended pregnancy
- Illicit drug use
- Financial and non-financial barriers to health care
- Inadequate resources to cope with difficult life circumstances
- Lack of control over one's economic, physical and social environments. [40] [41]

Changes in these unmeasured risk factors may have contributed to both the decline in infant mortality in low income areas as well as in the population as a whole. The Infant Mortality Review collected information on some of these unmeasured factors, which are described in Chapters 6-9, but accurate population-based estimates of their prevalence and trends over time are unavailable.

WHY ARE RISK FACTORS CHANGING?

While it is clear that risk factors for infant mortality have declined, the reasons for this favorable trend are complex and not fully understood. However, recently implemented important advances in the delivery of health and social services to pregnant women appear to have contributed to the declining rates of risk factors for infant death.

MEDICAID EXPANSION

In July of 1987, Washington State implemented changes in the state's Medicaid health insurance program to increase the number of pregnant women eligible for Medicaid coverage, regardless of their eligibility for financial assistance (see Appendix A under "Medicaid" for more information). Medicaid is a government program that pays for the medical care of people with low incomes. These changes increased the income threshold for eligibility for Medicaid for pregnant women from sixty percent of poverty ($7,588 annual income for a household of four in 1989) to ninety percent of poverty ($11,382 annual income for a household of four in 1989).[42] Expanding the number of women eligible for Medicaid increased the proportion of women with health coverage and thus removed an important barrier to obtaining prenatal and obstetrical care for many low income pregnant women. Women who receive prenatal care are more likely to:

- Refrain from smoking, alcohol consumption and other behaviors associated with poor birth outcomes
- Have complications of pregnancy diagnosed and treated
- Have symptoms of preterm labor more aggressively managed
- Have more social support.

Thus, expanded access to prenatal care through the Medicaid program may have reduced the frequency of risk factors for infant death.

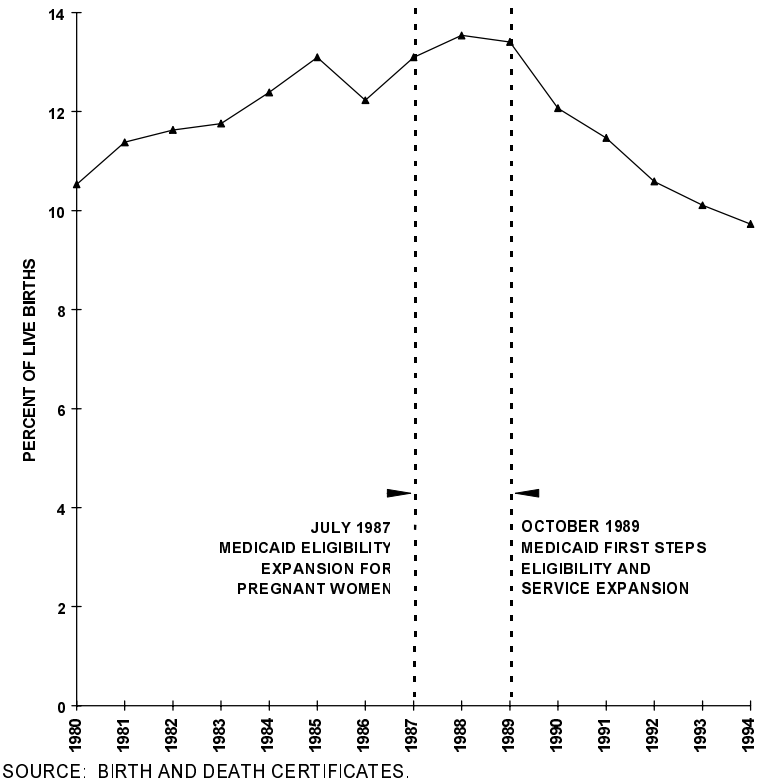
THE FIRST STEPS PROGRAM

Washington State enacted the Maternity Care Access Act in 1989. Known as the "First Steps" program, its goal was to provide maternity care to promote healthy birth outcomes for low-income families. The program included:

- A further expansion of Medicaid eligibility from 90 percent of federal poverty to 185 percent of the federal poverty level
- The addition of maternity support services (e.g., community health nursing visits, nutrition services, childbirth education and psycho-social counseling)
- Case management for women at high-risk of poor pregnancy outcomes
- Increased reimbursement for maternity care providers
- Accelerated application and eligibility determination processes
- A statewide public education campaign
- Assistance with transportation and child care for medical appointments.

The program also made pregnant women the highest priority for substance abuse treatment.

FIGURE 2.10
PERCENT BIRTHS WHERE MOTHER RECEIVED INADEQUATE PRENATAL CARE (KOTELCHUCK)
KING COUNTY
1980-1994



SOURCE: BIRTH AND DEATH CERTIFICATES.

The implementation of these programs resulted in Medicaid becoming the single largest payer for maternity services in Washington. The proportion of births covered by Medicaid statewide increased from 24 percent to 35 percent.[44] Evaluation of First Steps [43 44] found improvement in both access to care and birth outcomes. Fewer Washington women received late or no prenatal care following implementation of First Steps (Figure 2.10). The low birthweight rate declined for low-income births following the initiation of this program.

Local data confirmed these findings for King County. The expansion of coverage and maternity services in the late 1980s was associated with a reduction in the proportion of pregnant women in King County who received inadequate prenatal care.

KING COUNTY INITIATIVES TO PROMOTE MATERNAL AND INFANT HEALTH

In addition to the First Steps Program, several additional local initiatives to improve maternal and infant care have been implemented in King County in recent years. These programs may also have contributed to the observed improvements:

1982 - Maternity screening services were established by the Health Department and community clinics to promote early entry of pregnant women into prenatal care and utilization of state Prenatal Care funds. Virginia Mason Hospital received a Kellogg Foundation grant to establish the Community Obstetric Referral Program, which linked pregnant women with physicians accepting new obstetrical patients. Maternity Network meetings to share information and coordinate scarce prenatal care resources began.

1987 - Health Department maternity screeners used expanded Medicaid access to increase the number of women getting prenatal care in their own communities.

1989 - Maternity Network agencies worked collaboratively to educate patients and providers about First Steps and to develop Maternity Support Service teams in each clinic and WIC (Women Infant and Children Food Supplementation Program) site. By the end of 1990, 70 percent of pregnant women covered by Medicaid had received at least one Maternity Support Service.

1991 - The Health Department used state grant funds to contract with community agencies to begin outreach programs to prevent infant mortality. The programs were targeted to minority populations in Central and Southeast Seattle and focused on pregnant women and families with infants.

1992 - The Health Department's Infant Mortality Review began. The City of Seattle expanded the infant mortality outreach projects which had been initially supported through state funds.

1993 - Both the City of Seattle and King County recognized the importance of home visiting to families of newborns and funded additional Health Department nurses to reach new families.

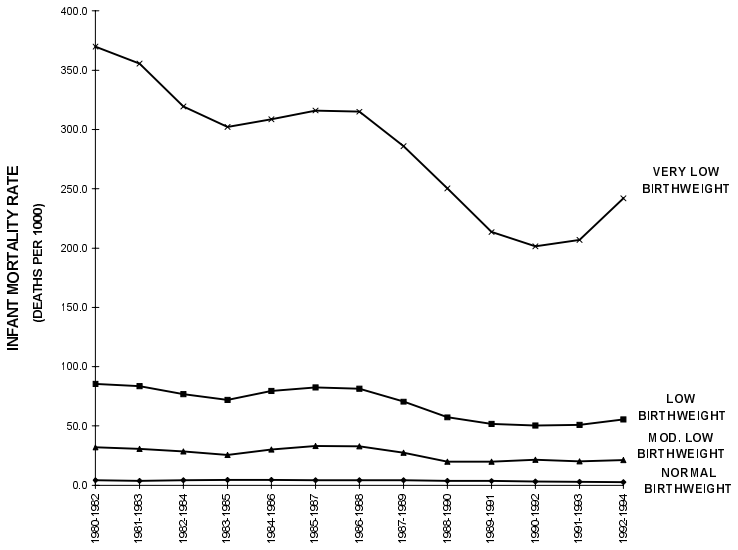
1995 - The University of Washington Medical Center expanded funding to the infant mortality outreach projects to enhance collaborative efforts for their clients. The King County and Washington State Health Departments launched the "Back to Sleep" Campaign to promote and reinforce the importance of placing infants on their backs rather than on their bellies to sleep.

ADVANCES IN MEDICAL CARE

Recent advances in the care of sick newborns have also made important contributions to the declining infant mortality rate. [45] These advances have made their impact through improving the survival rates of preterm and other sick newborns..

The decrease in mortality from prematurity and low birthweight described above was due to the improved survival of preterm and low birthweight infants. The rate of preterm births actually *increased* during the past 15 years, while the rate of low birthweight and very low birthweight infants did not vary substantially.

FIGURE 2.11
BIRTHWEIGHT SPECIFIC MORTALITY RATES
KING COUNTY
1980-1994



*TRENDS FROM 1980 TO 1994 ARE STATISTICALLY SIGNIFICANT
SOURCE: BIRTH AND DEATH CERTIFICATES.

This interpretation is supported by the following analysis of birthweight-specific infant mortality rates. The death rate among infants with very low birthweight (<1500 grams) declined dramatically, by 32 percent, between the 1980 to 1982 and 1992 to 1994 periods (Figure 2.11). The mortality among moderately low birthweight infants also declined. Therefore, even though the same proportion of infants were born with very low and moderately low birthweights, because of their improved odds of survival, the mortality rate from prematurity and low birthweight decreased.

The finding of decreasing mortality rates among moderately low birthweight and very low birthweight infants was equally true for infants born to mothers living in high poverty areas and low poverty areas and for African Americans as well as whites.

Several major advances in medical treatment have contributed to improved infant survival, especially among premature infants. The immaturity of the lungs of preterm infants causes difficulties with breathing. The increasing use of the medication *surfactant* to improve the function of immature lungs has greatly improved the survival of premature infants.[46 47] Surfactant was first used locally at the University of Washington Medical Center in 1989, and its use spread throughout King County in 1990. Technologies used in neonatal care units also improved in recent years, including more sophisticated ventilators (devices that ensure optimum lung ventilation) and oxygen saturation meters (which continuously and easily track the level of oxygen in the blood to facilitate monitoring of lung function) .

However, as noted above, the decline in prematurity-related deaths has ceased in recent years. This trend may indicate that the potential of the recent advances in medical care has been fully realized and that further improvements will come only from measures which decrease the rate of preterm delivery. These measures may include new medical treatments (such as more aggressive treatment of certain female reproductive tract infections) [48] and social interventions aimed at reducing stress and increasing social support among pregnant women. [49]

Improved medical care may also partly explain the declining death rate from congenital anomalies. While the decreasing rate could be due either to a lower incidence of infants born with anomalies or a better survival rate of such infants, local experts have indicated that improved survival is the more likely explanation. Other factors may include routine availability of amniocentesis for women over 35 years of age to screen for Downs Syndrome, universal alpha-feto-protein screening for neural tube defects and more widespread use of high definition ultrasound to detect cardiac and other birth defects early in gestation.

CONCLUSIONS

In conclusion, the infant mortality rate in King County has entered a period of more rapid decline. Among all causes of infant death, the decrease in the SIDS rate made the largest contribution to this reduction. The encouraging trend may be explained by reductions in risk factors for infant death through expanded health services for pregnant women, advances in medical care and changes in infant sleep position.

REFERENCES

[1] Wise PH, Kotelchuck M, Wilson ML et al. Racial and socioeconomic disparities in childhood mortality in Boston. NEJM 1985; 313(6):360-66.
[2] Spurlock CW, Hinds W, Skaggs JW et al. Infant death rates among the poor and nonpoor in Kentucky. Pediatrics 1987; 80(2):262-69.
[3] Little R, Peterson D. Sudden Infant Death Epidemiology: A Review and Update. Epidemiological Reviews 1990; 12:241-246.
[4] Gould JB, LeRoy S. Socioeconomic status and low birth weight: a racial comparison. Pediatrics 1988; 82(6):896-904.
[5] Starfield B. Postneonatal mortality. Ann Rev Public Health 1985; 6:21-40.
[6] Shannon DC, Kelly DH. SIDS and near-SIDS. NEJM 1982; 306:961.
[7] Kleinman J, et al. Effect of Smoking on Fetal and Infant Mortality. Am J Epidemiol 1988; 127:274-282.
[8] Malloy M, et al. Association of Maternal smoking with Age and Cause of Infant Death. Am J Epidemiol 1988; 128:46-55.
[9] Cnattingius S, Haglund B, Meirik 0. Cigarette smoking as risk factor for late fetal and early neonatal death. Br Med J 1988; 297:258-61.
[10] Jones KL, Smith DW. Recognition of the fetal alcohol syndrome in early infancy. Lancet 1973; 2:99.
[11] Acker D, Sachs B, Tracy K et al. Abruptio placenta associated with cocaine use. Am J Obstet Gynecol 1983; 146:220-21.
[12] Chasnoff IJ, Burns KA, Burns WJ. Cocaine use in pregnancy: perinatal morbidity and mortality. Neurotoxicol and Teratol 1987; 9:291-3.
[13] Finnegan LP. In utero opiate dependence and sudden infant death syndrome. Clin Perinatol 1979; 6(l):163-180.
[14] Harris J. Prenatal care and Infant Mortality, in Fuchs V (editor): Economic Aspects of Health Care. Chicago: University of Chicago Press, p 15, 1982.
[15] Wise P, et al. Infant Mortality Increase despite Access to Tertiary Care. Pediatrics 1988; 81:542-548.
[16] Institute of Medicine. Preventing Low Birthweight. Washington, D.C.: National Academy Press, 1985.
[17] Krieger J, Connell F, LoGerfo JP. "Medicaid prenatal care: A comparison of use and outcomes for fee-for-service and managed care." Am J Pub Health 1992; 82(2):185-90.
[18] Piper J, Ray W, Griffin M. Effects of Medicaid Eligibility Expansion on Prenatal Care and Pregnancy Outcome in Tennessee. JAMA 1990; 264:2219-2223.
[19] Schwethelm 3, et al. Risk Status and Pregnancy Outcomes among Medicaid Recipients. Am J Prev Med 1989; 5:157-163.
[20] Olds D, et al. Improving the Delivery of Prenatal Care and Outcomes of Pregnancy: A Randomized Trial of Nurse Home visitation. Pediatrics 1986; 77:16-28.
[21] Newton RW, Hunt LP. Psychosocial stress in pregnancy and its relation to the onset of premature labor. Br Med J 1979; 2:411-413.
[22] Oakley A. Social support in pregnancy: the "soft" way to increase birthweight? Soc Sci Med 1985; 21:1259-68.
[23] Norbeck JS, Tilden VP. Life stress, social support and emotional disequilibrium in complications of pregnancy: a prospective multivariate study. J. Health Soc Beh 1983; 24:30-46.
[24] Kotelchuck M: An evaluation of the Kessner adequacy of prenatal care index and a proposed adequacy of prenatal care utilization index. Am J Pub Health 1994; 84:1414-20.
[25] Berendes HW, Forman MR. Delayed Childbearing: Trends and Consequences in *Reproductive and Perinatal Epidemiology*, Kiely M, editor; Boston: CRC Press, 1991.
[26] McIntosh LJ, Roumayah NE, and Bottoms SF: Perinatal outcome of broken marriage in the inner city. Obstet Gynecol 1995; 85:233-6.
[27] Willinger M, Hoffman HJ, Hartford RB. Infant sleep position and risk for SIDS. Pediatrics. 1994;93:814-819.
[28] Dwyer T, Posonby AL, Newman NM, Gibbons LE. Tasmania: the cohort study and a decline in SIDS rate during 1991. In: Walker AM, McMillen C, eds. *Proceedings 2nd Family International SIDS Conference*. New York, NY: Perinatology Press; 1993:35-43.
[29] Taylor BJ. A review of epidemiological studies of sudden infant death syndrome in southern New Zealand. J Paediatr Child Health. 1991;27:344-348.
[30] Mitchell EA, Ford RPK, Taylor BJ, et al. Further evidence supporting a causal relationship between prone sleeping position and SIDS. J Pediatr Child Health. 1992;28(suppl 1): S9-12.
[31] Wingfield RE, Fleming PJ, Berry PJ, et al. Can the fall in Avon's sudden infant death rate be explained by changes in sleep position? BMJ. 1992;304:282-283.
[32] *Report of the Chief Medical Officer's Expert Group on the Sleeping Position and Cot Death.* London: Her Majesty's Stationary Office (HMSO); 1993.

[33] Dwyer T, Ponsonby AL, Blizzard L, Newman NM, Cochrane JA. The contribution of changes in the prevalence of prone sleeping position to the decline of SIDS in Tasmania. JAMA. 1995;273:783-789.
[34] Taylor JA, Krieger JW, Reay DT, et al. Prone sleep position and the sudden infant death syndrome in King County, Washington: A case-control study. J. Pediatr 1996;128:626-30.
[35] Wise PH, Kotelchuck M, Wilson ML et al. Racial and socioeconomic disparities in childhood mortality in Boston. NEJM 1985; 313(6):360-66.
[36] Spurlock CW, Hinds W, Skaggs JW et al. Infant death rates among the poor and nonpoor in Kentucky. Pediatrics 1987; 80(2):262-69.
[37] Little R, Peterson D. Sudden Infant Death Epidemiology: A Review and Update. Epidemiological Reviews 1990; 12:241-246.
[38] Gould JB, LeRoy S. Socioeconomic status and low birth weight: a racial comparison. Pediatrics 1988; 82(6):896-904.
[39] Starfield B. Postneonatal mortality. Ann Rev Public Health 1985; 6:21-40.
[40] Melnikow J, and Alemagno S: Adequacy of prenatal care among inner-city women. J Fam Pract 1993; 37:575-82.
[41] Chomitz VR, Cheung L, Lieberman E: Healthy mothers-healthy beginnings. A white paper, Center for Health Communication, Harvard School of Public Health, grant funded by CIGNA Corporation, Harvard School of Public Health, 1992; 1-66.
[42] Cawthon L, Kenny F, and Schrager L.: The First Steps Expansion Group. A study of women newly eligible for Medicaid through expanded eligibility. Department of Social and Health Services, State of Washington, September 1992, p1.
[43] Connell FA, Balassone ML, Baldwin LM, et al.: First Steps evaluation report. August, 1993.
[44] Cawthorn L, Kenny F, Schrager L. The First Steps Expansion Group: A study of women newly eligible for Medicaid through expanded eligibility. Olympia, WA: Department of Social and Health Services, 1992.
[45] Jobe AH. Pulmonary surfactant therapy. N Engl J Med, 1993; 328:861-8.
[46] Crowley P, Chalmers I, and Keirse M: The effects of corticosteroids administration before preterm delivery: an overview of the evidence from controlled trials. Br J Obstet Gynaecol 1990; 97:11-25.
[47] Hoekstra RE, Ferrara TB, and Payne NR: Effects of surfactant therapy on outcome of extremely premature infants. Eur J Pediatr 1994; 153:S12-S16.
[48] Hauth JC, Goldenberg RL, Andrews WW, et al.: Reduced incidence of preterm delivery with metronidazole and erythromycin in women with bacterial vaginosis. N Engl J Med 1995; 333:1732-6.
[49] Rowley DL, Hogue CJR, Blackmore CA, et al. Preterm delivery among African-American women: A research strategy. Am J Prev Med 1993; 9(supp 2): 1-6.